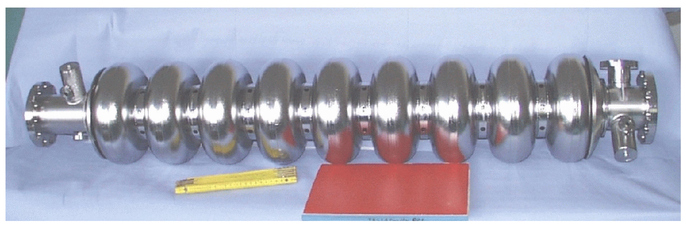
TeV Energy Superconducting Linear Accelerator

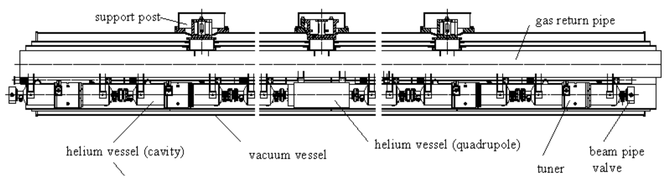
THE TESLA CRYOGENIC ACCELERATOR MODULES

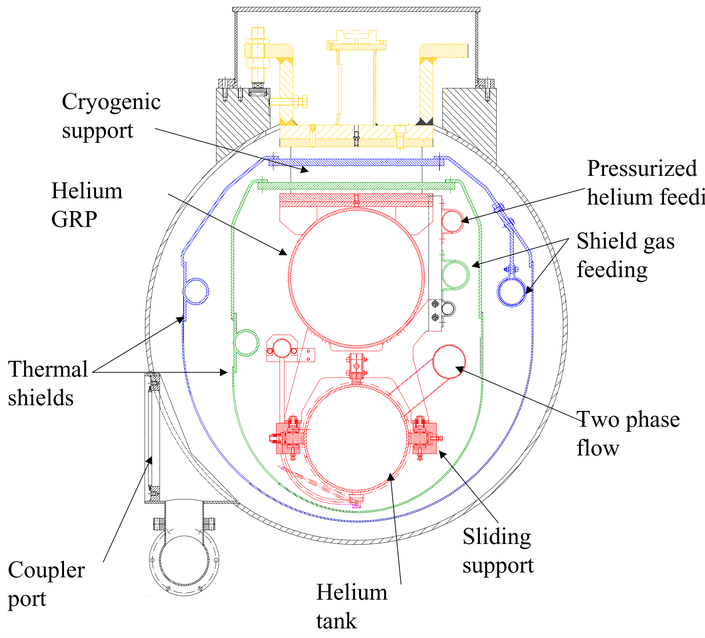
C. Pagani[1], R. Bandelmann[2], D. Barni[1], M. Bonezzi[1], G. Grygiel[2], K. Jensch[2], R. Lange[2], A. Matheisen[2], W.-D. Moeller[2], H.-B. Peters[2], B. Petersen[2], P. Pierini[1], J. Sekutowicz[2], D. Sellmann[2], S. Wolff[2], K. Zapfe[2]

[1]INFN Milano-LASA, Milano, Italy [2]DESY, Hamburg, Germany



Superconducting 9-cell cavity
1.038 m, pure Nb
>25 MV/m, Q_0=10^{10} at 2 K, total number > 21000

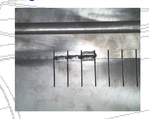


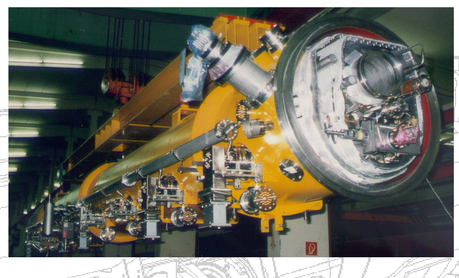


TTF Cryomodule Design

Three "generations" of the cryomodule design, with increasing simplicity and decreasing costs

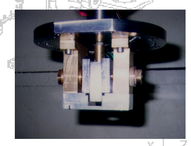
"Finger Welded" Shields





Sliding Fixtures

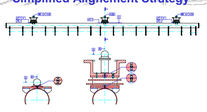
Sliding Fixtures Qualification Tests in LASA

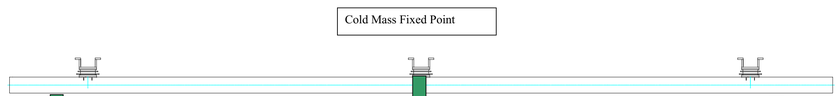


Characteristic and Performance

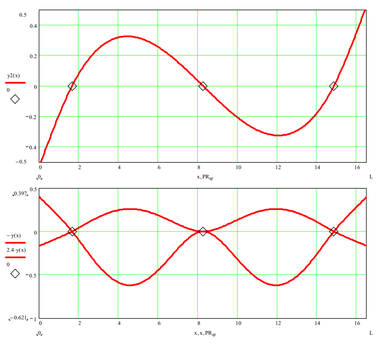
• Length	≈12	m
• # cavities	8	
• # quadrupole doublets	1	
• Static heat load @ 2 K	1.5	W
• Static heat load @ 4.5 K	8	W
• Static heat load @ 50 K	70	W

Simplified Alignement Strategy





- The TESLA cryostat is based on the third generation TTF cryostat.
- The main change is the length that has been increased to about 17 m.
- Support of the He GRP has been repositioned to minimize effect of beam bending to simplify manufacturing and to reduce fabrication cost.
- To reduce the sensitivity to external unpredicted force the quadrupole has been positioned below the central support that is the fixed point.
- In a 17 m cryostat the INVAR rod can not be used alone to compensate thermal shrinkage to use semi-rigid coupler. A solution with calculated reference point by thermal contraction compensation is presented using INVAR and 316 SS rods.
- Differential thermal dilatation is used to compensate effects.
- Differences between third generation TTF module and TESLA module are presented



Asymmetric force movements:

Quad: ~ 0mm

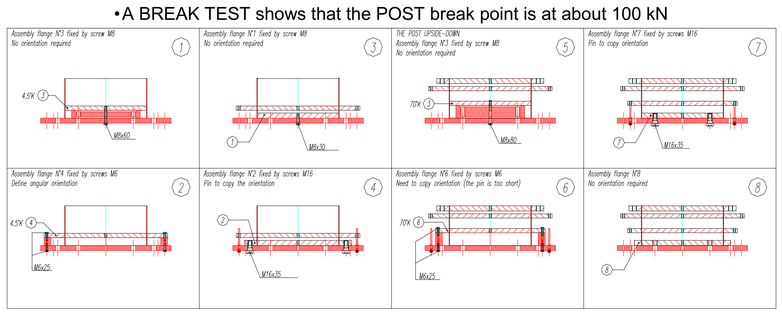
Cavity: 0.5mm

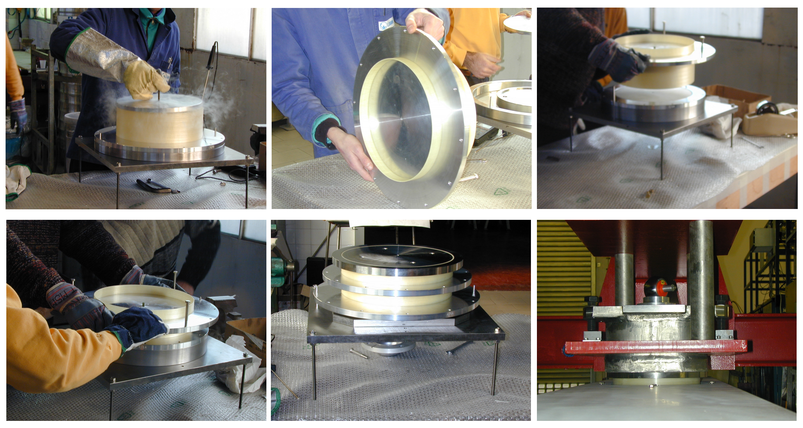
Manufacturing and assembly:

MAX Deflection 0.85mm

		CRY 3	CRY TDR 3 POST
Static Deflection (mm)		0.3	0.85
Quad	movement (mm)	~0	~0
	tilting (urad)	80	125
Cavity	movement (mm)	0.2	0.5
	tilting (urad)	180	380
Theramal Contraction (mm)		2.2	0.8

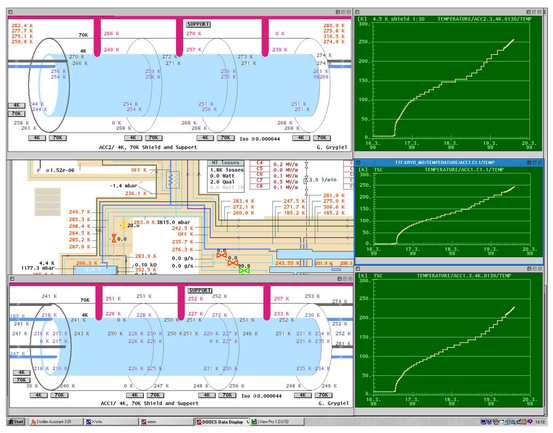
- Support posts are the mechanical cryogenic connections of the He GRP
- A fiber glass pipe dimensioned to keep the eigenfrequencies high is the insulating element
- Stainless steel and aluminum flanges are shrink-fitted for mechanical connection to GRP, thermal shields and room temperature support.
- Each support post has been tested by compression/tension cycles to verify the stiffness of the interference junction.
- A BREAK TEST shows that the POST break point is at about 100 kN



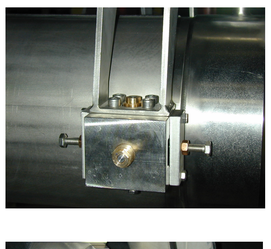


Kg	1		2		3		4	
	up	down	up	down	up	down	up	down
200	0	0	0	0.005	0.005	0.005	0.005	0.005
1000	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
2000	0.065	0.07	0.07	0.07	0.07	0.07	0.07	0.07
3000	0.1	0.1	0.1	0.105	0.1	0.105	0.105	0.105
4000	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
4510	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16

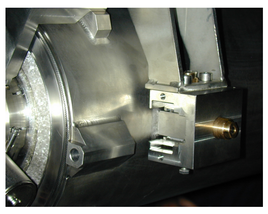
	Static [W]	Dynamic [W] Eacc = 23.4 MV/m Q_0 = 1 10^5 5Hz High Energy Beam	Add. Dynamic [W] 21.1 MV/m Q_0 = 1 10^5 5Hz FEWL Beam
2K			
RF load	-	4.95	3.99
Supports	0.60	-	-
Input Coupler	0.76	0.14	0.14
HOM Coupler	0.01	0.27	0.27
HOM Absorber	0.14	0.02	0.01
Beam tube bellows	-	0.24	0.20
HOM to structure	-	1.68	0.86
Instrumentation cable	0.13	-	-
Current leads	0.10	0.01	-
SUM	1.74	7.31	5.47
5-8 K			
Radiation	1.95	-	-
Supports	2.40	-	-
Input Coupler	2.05	1.19	1.15
HOM Coupler	0.40	2.66	2.66
HOM Absorber	3.1	0.77	0.37
Instrumentation cable	1.39	-	-
SUM	11.32	4.62	4.18
40-80 K			
Radiation	44.99	-	-
Supports	6.00	-	-
Input Coupler	21.48	59.40	48.89
HOM Coupler	2.55	13.22	13.22
HOM Absorber		15.27	8.07
Instrumentation cable	-3.27	-	-
Current leads	5.38	5.00	-
SUM	90.13	92.89	70.18

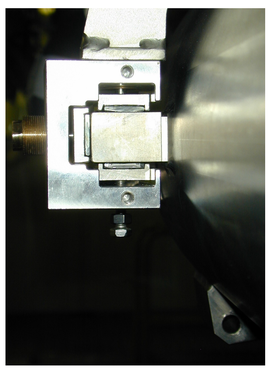


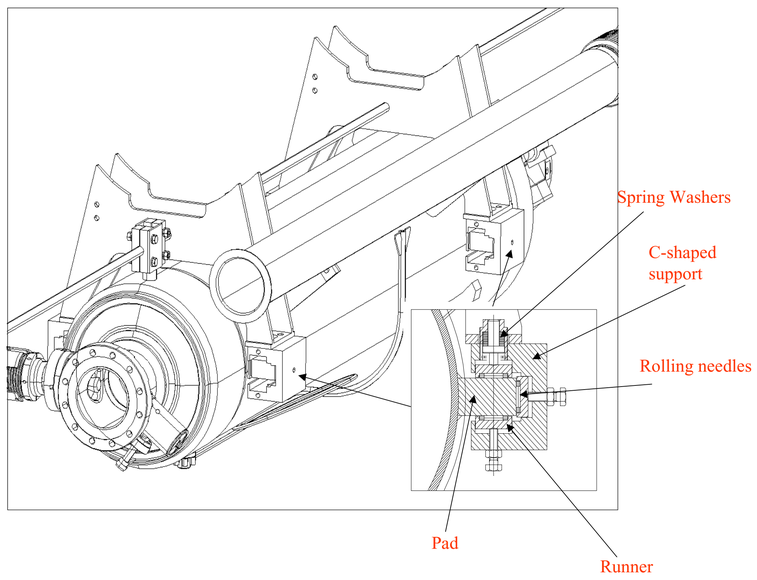
- The thermal heat loads have been computed both in static and dynamic operation.
- Dynamic operation supposed :Eacc =23.4 MVm, Q_0=10^{10} and an operation rate of 5Hz.
- The thermal shields are copied from 3rd generation TTF module. The "finger welding" technique links aluminum panels to the aluminum cooling pipe.
- The efficiency of welded shields has been demonstrated with FEM calculation and then verified during TTF operation.
- Cool-down of welded shields was faster and with small gradients producing small deformation on the cold mass



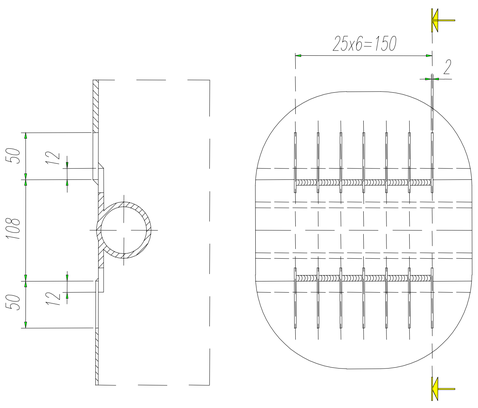
- Four C-shaped stainless steel elements clamp a titanium pad welded to the helium tank.
- Rolling needles reduce drastically the longitudinal friction
- Cavities are independent from the elongation and contraction of the HeGRP.
- Lateral and vertical position are defined by reference screws
- Longitudinal position can be fixed by the use of an Invar rod



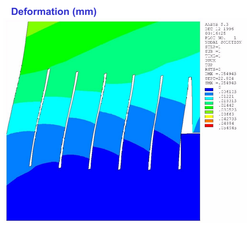




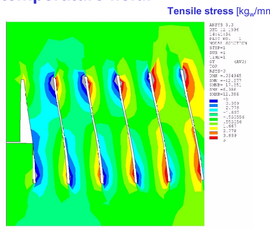
Finger welding FEM check in real temperature field.



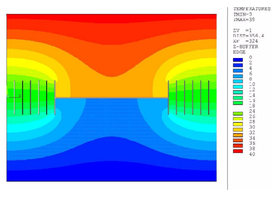
Deformation (mm)



Tensile stress [kg_f/mm^2]



Temperature field in the finger region for a ΔT of 40 K.



Von Mises stress [kg_f/mm^2]